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ABSTRACT

The general purpose of this project was to examine the process of becoming a scientist, from elementary school through four years of post-college work. Seven hundred male students in the Boston area, from 5 different grade levels (grades 5, 8, 11, 14, and 16), were studied for 5 years, thus covering a 16 year developmental span. Data collection included interviews of students and teachers, standardized achievement and aptitude tests, personality and interest inventories, questionnaires for students and parents, and two projective instruments. The term "Potential Scientist Pool" (PSP) was defined. The boys involved in this study were chosen from the PSP at all grade levels. Movement into or out of the PSP was determined during the 5 years of the study. The rationale behind this experimental design is discussed in detail. (Author/BB)

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CAREER DEVELOPMENT OF SCIENTISTS:

AN OVERLAPPING LONGITUDINAL STUDY

An Interim Report

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The research reported herein was performed pursuant to a contract with the U. S. Office of Education, Department of Health, Education, and Welfare. Project Number 436.

September 1959

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Preface

In June, 1958 the U. S. Office of Education made a grant to the Graduate School of Education at Harvard University to undertake a five-year study of career development, with special attention to the scientific career. The project began July 1, 1958 and the expected date of completion is June 1963. This interim report has been prepared in order to give a more detailed description of the first year's progress than has been possible in the brief quarterly reports. It is also hoped that this report will serve as a working paper for purposes of discussion with staff, consultants, participating school administrators, government sponsors, and graduate school seminars. It is to be considered only as a tentative working paper, and it is not expected that any portions of this paper are suitable for publication at the present time.

William W. Cooley
Principal Investigator

Cambridge, Mass.
September, 1959

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A BRIEF DESCRIPTION

The general purpose of this research project is to examine the process of becoming a scientist, from elementary school through four years of post-college work, in order to determine the major factors affecting that process. We are working toward this broad goal by attempting to:

1. Establish tests and procedures for handling test data which will provide information for students making career decisions as they move through the schools.
2. Determine the environmental factors which seem to affect career decisions at the various choice points during educational development, especially those aspects of the environment over which educators have some control.
3. Identify in what ways various current practices in science education affect the student's consideration of science as a possible vocational area.

The overlapping longitudinal design involves selecting 700 male students from five different grade levels, three years apart, and studying them concurrently for five years. This way a sixteen-year developmental span will be studied in only five calendar years. The two years of overlap between the five groups will allow comparisons between the groups. It is not our desire or expectation to be able to predict which fifth graders will become Ph.D's in theoretical physics, but rather to identify factors which are related to career decisions made at the various stages of educational development.

THE RATIONALE

Any investigation is guided by certain preconceptions of the investigator, and when stated formally, they serve as the rationale of the investigation. This rationale in turn serves as the basis for explaining and describing the decisions made during the course of an investigation. The rationale set forth here is primarily a synthesis of ideas gleaned from several sources over the past three years. The author is particularly indebted to reports issued by the Harvard Studies in Career Development under Dr. David Tiedeman's direction, and the monograph summarizing the work of the Advisory Panel of the Scientific Careers Project compiled by Super and Bachrach[1].

Theories of Vocational Choice:

In reading discussions by psychologists and others who are attempting to guide research in career development, one constantly encounters the term "theory." In many cases this is a rather weakened use of a word which has a significant meaning in organized knowledge, but which is slowly becoming distorted to the point of being unrecognizable. A theory is a research tool. It is a tight deductive system that generally involves a physical or mathematical model and a set of assumptions or propositions which are provisionally accepted on faith. The theory is designed so that previously observed relationships can be deduced from it. Its research value stems from the fact that it is also possible to deduce new, previously unobserved relationships from such a deductive system. The functional relationships are what the technologist makes use of, and the theory is only a means of assisting the "discovery" of new relationships. Theories

[1] D. E. Super and P. B. Bachrach, Scientific Careers and Vocational Development Theory, Horace Mann-Lincoln Institute of School Experimentation, Teachers College, Columbia U.: New York, 1957.

have been especially necessary in the physical sciences, where it is often difficult to arrive at fruitful research procedure any other way. They have been especially successful in that area because mathematical laws have been available upon which these theories could be built.

On the other hand, the phenomenon of career development, although long a concern of man, has only recently become a subject of scientific investigation, and observed relationships which evoke confidence are few. Therefore, the "theoretician" in this area is forced to develop a priori, arm chair schemes based on a few slight group tendencies. The authors of such schemes choose to label them "theories" since they are attempts at guiding research, but it must be remembered that such theories differ extensively from those which have proven so successful in the physical sciences. A well-grounded deductive system, built upon observed relationships, is much more likely to yield hypotheses which survive empirical test than a scheme based upon "it-seems-to-me" speculation. It is not surprising, then, to find such schemes crumbling as fast as they are built. Perhaps it is desirable to take a little closer look at this career choice process, improve the measurement procedures being used, and uncover a few more reproduceable relationships before further elaborate schemes are developed.

Besides this a priori nature, there are other difficulties with the "theories" or "frameworks for research" available to the worker who wishes to conduct research in this area. One is their extreme breadth. Unified theories are proposed which attempt to explain the whole process of career development, from birth to death, for males and females, rich and poor, intelligent and retarded, professional and unskilled, all in one grand scheme. Certainly this is an ambitious project in such a new science.

Another difficulty is that the theories are seldom operational. Because they tend not to be reconstructions of empirical, reproduceable findings, they frequently become involved in words and phrases which sound convincing but which do not suggest operations. Nothing is more useless to the research worker than slippery verbiage which cannot be translated into research procedures.

However, some frame of reference is necessary. It is not possible to measure everything in the hope that some significant relationships will be found. One must make certain decisions about what to measure and when, and there needs to be a rational basis for such decisions. Because I am now actively engaged in the study of scientific careers, I have been forced to develop an operational scheme in which concepts are defined in terms of definite measurement procedures. Since I am concerned only with entrance into scientific careers, the necessity of a broad, all-encompassing scheme is avoided. Finally, because too few stable relationships are known, the guiding scheme is necessarily a rationale with some flexibility, rather than a deductive system yielding specific hypotheses. A claculated risk is always necessary in research, but it is probably too hazardous to devote an entire five-year study to the testing of one specific hypothesis derived from an a priori theory of the vocational choice process.

Basic Definitions:

In discussions of this sort it is always necessary to clarify a few terms which often have several different meanings in everyday discourse. These definitions are not as rigorous as thet might be, but at least they sould help to diminish some of the confusion which inevitably results when the scientist moves into a "familiar" domain such as the world of work. The following terms include modifications of definitions found

in Tiedeman[1] and Super[2].

Position: That specific activity or set of activities with a market value which an individual usually pursues for the purpose of obtaining income. There are at least as many positions as the total number of people employed, with some people occupying two or more positions.

Career-goal: A real or imagined type of position or sequence of positions toward which an individual aspires during the preparatory period of his life. Not all students have career goals.

Career: The sequence of positions which a person holds throughout his life.

Occupation: A category used for classifying similar types of positions, similarity usually determined by worker function.

Vocational behavior: Behavior which is directly related to the individual's career. We are particularly concerned with those aspects of vocational behavior which are related to pursuit of and preparation for types of scientific careers.

Scientific careers: Individuals are considered to be pursuing scientific careers whose educational decisions and sequence of positions involve working toward or in positions which require at least a four-year college major in one or more of the natural sciences or engineering. The "scientific career" is not being studied as a common effect for which a common cause is sought,

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[1]D. V. Tiedeman, & R. F. O'Hara, Position choices and careers: elements of a theory. Harvard Studies in Career Development, No. 8. Mimeographed, Harvard University: Cambridge, 1958.

[2]D. E. Super, et al. Vocational Development: A Framework for Research. Teachers College, Columbia U: New York, 1957.

but rather we are examining patterns of vocational behavior within this category. Students who are consciously heading toward scientific careers are said to be in the potential scientist pool (PSP).

Attribute variables: Those measurements made on an individual which require him to behave: that is, the variable is a number based on the individual's response or set of responses to particular stimuli. Ability and personality measures are considered attributes.

Environmental variables: Those measurements made on an individual which do not require him to behave in any particular way for the measurement to take place, but which can be obtained from observing his social and physical surroundings or by determining group membership which may partially define probable surroundings. ("Group membership" usually being due to circumstances of birth, e.g. sex, race, nationality, religion, family socio-economic status.)

A Developmental Approach:

One promising recent trend in the study of vocational behavior has been to use a developmental approach. From this point of view, a career in science is not something which is thought to be chosen at any particular grade. Choosing a career in science is a process which takes place over a long period of time and which is determined by the individual's attributes and environment and their interaction. Although the decision to embark upon a scientific career cannot be considered as a single event occuring at some point in time, certain crucial educational decisions (which are aspects of vocational behavior) are made as an individual moves through the schools. These decisions, which are forced at several stages of educational development, affect the career possibilities in science and

technology open to an individual when he terminates his education. Because of the specialized nature of work in science and technology, it seems reasonable to expect that after a certain stage of development is reached (perhaps somewhere in senior high school), changes in the potential scientist pool are essentially a one-way proposition -- out. The point at which the PSP reaches its recruitment limit will be examined in this investigation.

This hypothesis that by the end of senior high school migration is essentially out of, but not into, the PSP is supported by studies of changes in major field of concentration during college. For instance, Joseph Cole[1] in a study conducted at the University of Rochester found that 311 students, of the 759 whose records were examined, changed their major before graduating. of these 311 migrations, 167 of them involved movement out of the science and technology fields and 72 of them were migrations between science fields. Only eight students moved into one of the science fields from a non-science field. A second check sample showed that of 168 migrations, 140 were leaving one of the science fields, while only two students moved in. In terms of the total number of students initially enrolled as science and technology concentrators, this represented a loss of about 40%.

Studies of Group Differences:

Most previous efforts toward predicting vocational behavior have attempted to distinguish among occupational groups on the basis of certain measurements made of members working toward or in those occupations. Numerous group tendencies have been observed, but these relationships are so slight that they have almost no predictive value. In an effort to

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[1] J. W. Cole, The effect of migration of the multivariate test score distribution patterns for college students classified according to curriculum groups. Unpublished Ed.D. dissertation, Harvard University, Cambridge, 1958.

take into account the multiple test score information of individuals, very elaborate methods of multivariate analysis have been employed and prediction has been improved a little, but efforts to include more and more observations on more and more variables (which proved possible with the advent of the electronic computers) have not brought much further success.

One way prediction might be improved is to seek criterion groups more homogeneous with respect to the measurement procedures available. There is, after all, nothing sacred about any scheme for classifying occupations. As Bruner and others have pointed out, "Science and common-sense inquiry alike do not discover the ways in which events are grouped in the world; they invent ways of grouping. The test of the invention is the predictive benefits that result from the use of invented categories."[1] There is no reason to be bound to occupational categories which were not evolved for purposes of predicting vocational behavior. Of course, if one is interested in the technology as well as the science of this process, categories must be functional for guidance purposes. To tell a person that he exhibits "type Q" vocational behavior will be of little value if that does not provide him information for making certain educational decisions, such as choice of college major. But perhaps it is possible to devise functional criteria which are related to measurable attributes, rather than continue to search in vain for instruments which can predict eventual membership in arbitrary categories.

This belief that it is more expedient to search for criteria which are related to measurable attributes stems from a faith in multivariate procedures for handling personality and ability information. This is not to imply that factor analysis can identify the unique set of attributes,

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[1] J. S. Bruner, J. J. Goodnow, & G. A. Austin, A Study of Thinking. John Wiley & Sons, Inc.: New York, 1958, p. 7.

but that a set of independent (in the geometric sense) attributes can serve as a valuable frame of reference for describing individuals. Principal component analysis can identify basic, independent dimensions along which individuals differ, and once the unique relative position of each individual in the resulting attribute space is determined, regions can be located in this space which indicate similar vocational behavior.

This adherance to a factor approach to personality theory is based on the same reasoning which has no doubt led many other investigators in this area to use some sort of factor theory. It is one of the few personality theories which suggest definite operations. It is my belief that a reconsideration of the criterion which we are attempting to predict and modifications involving a developmental point of view will salvage this operational approach.

Ego and Self-Concept:

As mentioned above, the tendency has been to make certain measurements of attributes and environment and, from these to predict vocational behavior by attempting to find patterns among the predictors for certain occupational groups. One reason already mentioned for the inefficacy of this approach is the arbitrary way in which positions have been combined into these criterion groups.

Tiedeman suggests that the difficulty in the past has also been due to neglect of the ego's perceptions, which is a variable intervening between the usual predictors and the criterion. Reference to Figure 1 may help to clarify this point. What is important is not an outside observer's perceptions of the subject's attributes and environment and their relation to possible career goals or positions, but rather the individual subject's perception of them. Choosing among possible positions is considered to be

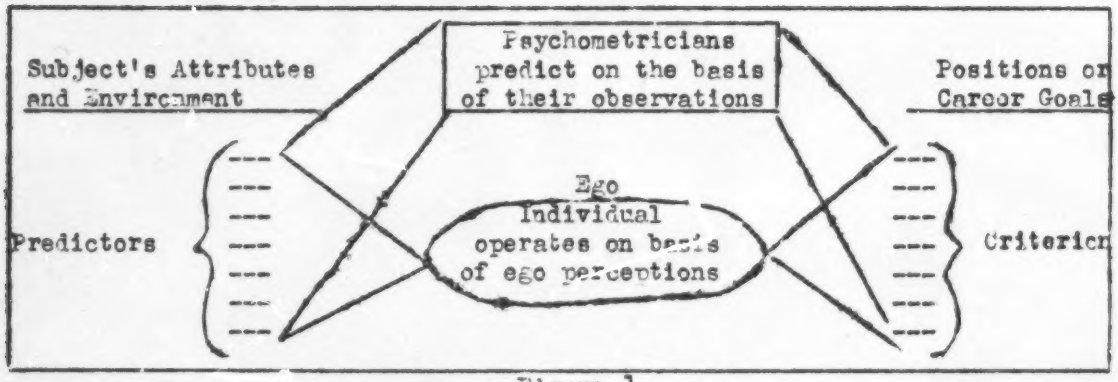

Figure 1

a process in which the subject finds a close fit between his self-concept and his perceptions of the positions he is considering, and his perceptions of both predictors and criterion may differ from the outside observer's.

Ego and self-concept are perhaps interesting and useful theoretical constructs but their use in a predictive system presents difficulties. The problem, of course, is measuring "intangibles" like self-concept. However, Tiedeman's argument is so convincing that one is forced to consider it. Either the measurement problem must be solved or it is necessary to present a convincing scheme which does not require making measurements of self-concept and the ego's perceptions of the world of work. Since I have found no convincing way to achieve the former, the alternative is considered here next.

The first task must be a clarification of what is to be predicted. The goal here is highly pragmatic. We are interested in minimizing the trial and error time usually involved in seeking out a suitable career. By making more reliable information available to individuals who are considering careers in science we hope to make the process of choice a more realistic one. It would also be useful to determine ways in which current practices in science education affect this choice process. It is my belief that these goals can be accomplished by attempting to develop a criterion

which involves the stability of membership in a group rather than membership itself. Predicting the probability of remaining within the potential scientist pool (for pre-college groups) and the probable stability of a particular career goal within science (for the college groups) are examples of such a criterion.

The criterion which Tiedeman proposes and which seems to be generally accepted is the "kind, duration and sequence of positions a person will occupy."[1] This is somewhat different from the criterion mentioned above. Certainly if one wants to predict which position or kind of position an individual will choose at some future date, one needs to know which positions an individual is considering and the individual's projected perceptions of himself in those positions. It is my opinion, however, that a more feasible and still fruitful approach is to assume that the kind and sequence of positions is indeterminate, since this involves anticipating certain experiences of individuals which are largely due to coincidence. It is possible that some day stochastic models can be developed which incorporate probability statements about the likelihood that the awareness of a particular kind of position is available in a particular region of an environmental space, but this is not the goal here.

If the criterion is instead the probable duration of a particular type of career goal, are measurements on ego perceptions necessary predictors? I think not. Refering back to the model in Figure I, the individual is said to seek out a position which the ego perceives has properties (e.g., basic function performed, level of difficulty, type of work settings, prestige level, type of reward, and style of life associated with it) consistant with its self-concept. If, after more experience his perception of a possible position or his self-concept changes so that inconsistencies

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[1] Tiedeman & O'Hara, op. cit.

arise, the individual will change his career goal. Change may also result when the individual becomes aware of a new position or type of position which to him seems more consistent with his self-concept.

Now consider the following two assumptions, keeping in mind the proposed change in the criterion and the model presented in Figure I:

1) An individual's perceptions of himself and of possible occupations become more realistic (become more congruous with the consensus of outside observers) with increased experience in the outside world (i.e. "realism" increases with time among active, intelligent humans who do not exhibit signs of serious neurotic or psychotic disturbances.)

2) Individuals with certain similar attributes would tend to find similar kinds of career goals unsuitable for them after increased experience and would then change to a new career goal if a more suitable one is presented. ("Similar" is left undefined for the moment; admitting the possibility of such similarities is all that is needed for now.)

Accepting these two assumptions as tenable, it seems reasonable to expect that satisfactory predictions about the stability of a given career goal can be obtained from equations based on observations of attributes and the duration of career goals. The same could be claimed for types of positions.

The individual's perceptions of himself and of occupations may be included in a scheme designed to explain the observed changes in the phenomena, but they are not a necessary component of the predictive system, at least not for the stability criterion described above. Perhaps an example will help to clarify this point. Eighty-six of the 192 eleventh grade boys now in the five-year study have professional engineering as a career goal. We have made n measurements on these eighty-six subjects, and each one has a unique location in an n-dimensional space whose coordinates

are these n measurements. During the next four years a large number of these boys will change from engineering as a career goal. It is our expectation that we can write equations based on the n-measurements of these boys, which will indicate the probable stability of engineering as a career goal for different regions of this n-dimensional space. We do not expect to predict which individuals will change from engineering nor to what the change will be, but rather what proportion of any given region of the predictor space can be expected to change.*

To be able to predict what will replace the engineer goal for John Jones one not only needs measures of John's self-concept and his perceptions of possible careers, but one also needs to predict certain experiences which John will have over the time interval of the prediction. Even though one might claim to be able to assess John's self-concept, certainly his exposure to particular career possibilities, the nature of that exposure, and his perception of the experience, is essentially indeterminate at a previous point in time.

Devising Criterion Groups:

The problem of defining "similar kinds of career goals" remains, however, even when using the less ambitious stability criterion. It is necessary to decide what types of career goals are to be included in group A if one wants to make statements like: "People like you, John, that have tried becoming an A in the past have tended not to continue toward that type of position." The following two criteria for a suitable grouping procedure seem to outline what is needed:

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* A similar situation is found in atomic physics. It is possible to determine the relative stability of different electron orbits (energy levels) but it is not possible to predict which particular electrons will shift orbits. It is certainly not possible to predict the orbit in which any given electron will end up.

1) The occupational groups must be homogeneous with respect to the predictors being utilized. We could not expect to work out a prediction of probable stability of membership in a particular group if that group exhibited the same density in all regions of the predictor space as did the other groups. It is necessary to use variables which are functionally related to membership in the various groups, and homogeneity is a criterion for the existence of such relationships.

2) The preparation required of people occupying positions in a group must be considered in defining the group. This seems reasonable since the purpose of the entire operation is to provide information for making decisions about alternatives presented during the educative process. This suggests that it may be desirable to develop less specific types of categories for the earlier stages of development.

Using these criteria for grouping several published classification schemes were considered and none seemed satisfactory for one reason or another. Also, several empirical procedures which emphasized the need for homogeneity of predictors for a given group were examined but all seemed too laborious or artificial. Finally a procedure was developed which seemed promising, and this was tried using some of the eleventh grade data. (Details of this trial analysis are presented in Section V of this report.)

Very briefly, the procedure involves reducing the original predictor space to a few independent dimensions through component analysis, which determines the principal dimensions along which individuals differ. Each individual's coordinates in this reduced factor space are computed and these factor scores are recorded in deviation score form on individual summary sheets. This summary sheet also contains relevant information about career goals, parents' hopes, test data, etc.

Hyperoctants in this reduced space, whose n-dimensions are the significant principal axes*, are then inspected to determine what common vocational behavior (career plans) individuals exhibit who are located in the same region of this particular factor space. This inspection is carried out by simply sorting the summary sheets according to the patterns of plus and minus signs of the factor scores.

Once a trend is observed in the different regions, the factor space can be reduced still further by discriminant analysis. The criterion for this discrimination is arrived at on the basis of reported career plans (not necessarily career goals; the predictor space may only contain information about college or no-college). When the criterion is a two-way classification, computation of the discriminant function is extremely easy because the discriminant weights are proportional to the regression weights derived from multiple regression analysis and when the predictor variables are independent the labor usually involved in that analysis is greatly reduced.

The final multiple regression equations (two-group discriminant functions) then become the basis for predicting the probability of an individual continuing with his present career plans. Several previous efforts to predict change have used group centours as the predictor of change. Students were expected to change to groups for which they have a higher centour score. However, the centour may not be the most appropriate statistic for the purpose of predicting the change criterion which is being used

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* These principal axes do not represent unique dimensions since they depend upon the original information being analyzed, but the entire operation, beginning with the observation, can be specified to the extent that the procedure is reproduceable. The importance of this preliminary analysis is that it results in a substantial reduction of the data which need to be considered, results in more stable scores which are less susceptible to shrinkage, and simplifies subsequent analyses.

in this study. The centour is a description of the distribution about a particular group centroid and <u>does</u> give information about profile resemblance to a particular occupational group at a definite point in time. However, it does <u>not</u> give sufficient information about the predictor space region in which an individual is located nor the expected performance within a particular group; and probable stability of a particular type of career goal is more likely to be a function of these considerations.

For example, in the three group case the 50th centours might be plotted as in Figure 2. Students x and y, who are both members of group B, lie on the 50th centour of group B (i.e., 50% of group B members lie further from the B centroid than do x and y). We do not believe, however, the x and y are equally likely to change to career goals which lie outside of the group B category.

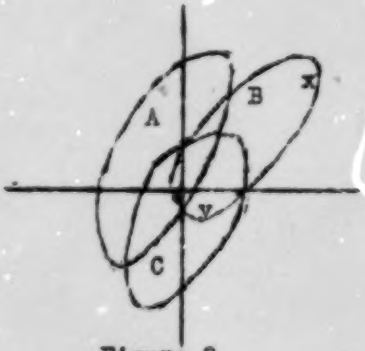

Figure 2

Even if one computes the centours of x and y for each of the three groups and attempts to make stability predictions on the basis of whether or not X is in the group for which he has the largest centour score, the centour system may break down. Itis conceivable that a certain region of the predictor space could yield higher centour scores on group A than on group B, and still be a region in which individuals tend not to leave group B. One reason for this is the fact that the centour ellipses are not always as neat and identical and Figure 2 suggests. I also personally

believe that it is more defensible to guide a man on the basis of what he has a reasonable chance of continuing in than to suggest he consider an occupation because members of that group are most like him. The danger that too great a homogeneity of groups would result from the incorporation of such a scheme is certainly something to consider.

It is not our intention to feed into one initial factor analysis all of the quantitative information that has been obtained on each subject. A more fruitful (and also less expensive) procedure is to deal separately with the observations of the individual's personality, ability, and environment. In this way the relative efficiency of these three systems of data for predicting stability of science career goals can be compared at each of the major decision points of career development. Each predictive system would offer quite different types of information for the guidance situation. For instance, it is probably more reasonable to discourage an individual from a scientific career if his location in the ability predictor space indicates very few from this region continue in science, than if his location in the environmental space indicates similar tendencies. In fact, the environmental predictors might be useful for identifying individuals who need encouragement to pursue a scientific career if ability and personality patterns indicate probable continuation but environmental observations do not.

Of course these efforts will not preclude the need to consider certain relationships between these three types of variables. The separation is only deemed advantageous in the consideration of the stability criterion.

SELECTION OF SCHOOLS AND STUDENTS

One of the first difficult tasks which faces an investigator who intends to empirically examine aspects of human behavior is the selection of the subjects to be studied. The following section of this interim report describes the procedures used in the selection of the students and the reasons for chosing those particular procedures.

Selection of Nine School Systems:

One of the major objectives of this study is to determine how to provide reliable information with which students can make more realistic educational decisions. It is not our intention to end up with normative data for immediate use in the schools, but rather to determine what type of normative data might be useful and feasible. For this reason, it was decided that a strict random sample of the student population was not necessary. However, a variety of schools and communities seemed to be desirable, not only to provide more representative findings, but to minimize the danger of over-taxing the patience of any one school system (an important consideration for a five-year study). A practical necessity was to use schools within a 25-mile radius of our center of operations, Harvard University. Since it was necessary in our design to draw students from three different grade levels within any given system, private schools were eliminated. Another reason for that decision was our desire to minimize the number of external variables in this study, yet still be able to generalize beyond one particular community. Finally, it was decided that about ten school systems would make it possible to keep the number of boys to be tested at any one time and place below thirty, thus minimizing the difficulties involved in scheduling tests, finding space for the testing, etc.

Using the above rationale, the nine school systems were selected in the following manner. Fifteen communities were randomly chosen from those within a twenty-five mile radius of Cambridge. Two communities without their own high schools were eliminated and the remaining list was discussed with Harvard faculty familiar with the schools in this area and with personnel at the Massachusetts Department of Education to obtain opinions on any schools which might present difficulties during a longitudinal study such as this, and to make certain that variety was achieved. Ten communities were selected as a result of these discussions. One additional school system was recommended because of its proximity to Harvard, but it was not possible to secure their cooperation, and so no additions were made to the original list.

The superintendents of ten systems were personally contacted during July, 1958, and all agreed to cooperate with the project. It later was learned that the smallest community contacted did not have any eleventh grade boys who met our selection criteria, and so the remaining nine are the communities actually being used. An idea of their relative sizes and certain economic factors can be obtained from Table I below.

Table I
(figures available Sept., 1958)

City or Town	Superintendent	Pop. 1955	Average daily Attend.	Pupil-teacher ratio	expend. per pupil
Somerville	L. C. Donahue	97000	10760	23.3	$303
Brockton	E. A. Nelson	63000	10495	28.5	212
Framingham	R. N. Anketell	32000	6192	26.7	273
Winchester	H. V. Gilson	18000	3462	26.7	305
Wilmington	J. J. Collins	9400	2421	29.0	201
Maynard	A. Lerer	7000	1221	26.1	210
Weston	A. G. Brackett	6000	1610	22.3	327
Millis	G. C. Roy	3030	777	26.8	218
Stow	R. C. Glidden	2200	462	25.3	234

Selection of the Colleges:

Some of the analyses which we expect to conduct involve comparisons between adjacent age groups. For instance, we would like to see if the equations which are developed from the analysis of test data for the college sophomore group are valid for predicting certain aspects of vocational behavior for the eleventh grade group as they reach that stage of development four years hence.

For that reason it was desirable to draw the college students from the colleges which the graduates of our nine school systems most frequently attend. This information was secured from the nine cooperating schools, and the colleges most frequently attended by their graduates were: Northeastern University, Tufts University, Boston University, University of Massachusetts, Boston College, Massachusetts Institute of Technology, and Harvard University (in order of frequency). The University of Massachusetts was eliminated because of its distance from Cambridge and the appropriate deans of the first five college were contacted. All agreed to cooperate. Harvard was added later in an effort to include more science students from a liberal arts college.

Selection of the Students:

Since our focus is on entrance into careers in the field of science and technology, it is necessary to include enough "future scientists" to talk about. However, it is not desirable (nor possible) to include only those heading toward scientific careers, for this would make comparisons impossible. It was therefore decided to utilize what is now known about scientific careers and eliminate certain segments of the school population for which entrance into scientific careers was extremely unlikely. The students were then randomly selected from among the remaining eligible

population.

Eligibility was determined by use of the following selection criteria:

1) Since the process of vocational development for girls is considerably different than it is for boys, and since girls tend not to go into scientific careers, it was decided to include only boys. To also study girls would require doubling the entire operation, since girls data would have to be kept separate from boys.

2) All fifth and eighth graders must have been above the 50th centile on all previously administered tests of general intelligence and in school achievement.

3) All eleventh graders must have been above the 50th centile in general intelligence and school achievement and are taking the college preparatory curriculum.

3) The college boys are all majoring in science, mathematics, or engineering, and graduated from high schools for which our nine school systems are representative (eastern Massachusetts).

The following table shows the school grades that will be covered by the five groups and the number of students included in each.

Sample Group	Number	Grades Covered
A	143	5 6 7 8 9
B	167	8 9 10 11 12
C	192	11 12 13 14 15
D	105	14 15 16 + +
E	90	16 + + + +
Total	697	

The sample size is small enough to permit the careful study of individual students and the various determinants of their career development. However, the sample sizes are sufficiently large to make applicable modern

techniques of multivariate analysis and to thus make possible the search for general principles.

Using the selection criteria described above, about one half of each of the 5th, 8th, and 11th grade groups are boys who, at this time, are heading toward careers in science. Since we believe that a career in science is one of the self-initiated careers (i.e., one has to consciously head toward it, rather than simply deciding after formal education is completed to go into science, as one can in many occupational areas), only those who profess a career goal in the sciences are considered to be in the potential scientist pool (PSP). As the rationale discussion pointed out, the task now is one of attempting to devise procedures for predicting migration out of this PSP. It will also be interesting to observe which boys will move into this manpower pool during the next four years. It is not expected that this movement into the PSP is predictable, either for individuals or the aggregate, but that the probability of this being a realistic (i.e., stable) career goal for these immigrants is predictable. It is not possible (because of the small numbers involved) to attempt to predict changes in career goals <u>within</u> the general PSP at these early stages, nor is it necessary for guidance purposes, since the early educational decisions are essentially the same for the entire PSP.

It may be possible, however, to distinguish among types of careers within the PSP for the two college groups, since they are all now within the PSP. This is also the time at which more specific guidance information is needed for making educational decisions about specific course work within the sciences.

<u>Securing Student and Parent Cooperation</u>:

It is one thing to draw 700 names from a "hat" of eligibles, but it is quite another to get those selected to agree to cooperate. No difficulty

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to schedule and complete all testing for that school system. Each school presented peculiar scheduling difficulties and these were worked out between the staff member and our contact at that school, usually the principal or guidance director. The usual procedure involved scheduling one class period of testing for each of the three grades in a community for one day, and then making about four or five such trips to each community. In this way the testing was not too concentrated for any individual or school, yet travel to the communities was not excessive. The school testing was begun in October and was completed by the second week in December.

The Rorschach and career interviews conducted in the schools presented very few difficulties, the major one being space when several interviewers were operating in the same school building on the same day. Only a few schools are equipped with conference rooms, so the interviews were conducted under varying, but usually adequate, conditions. (In fact the cooperation was so good that at times the principal gave up his office for a morning so that the interviews could be conducted in private.)

The college testing was more difficult. The deans could only agree to let us contact their students, but the task of getting them to come to the right place at the right time was ours. The general procedure included obtaining everyone's class schedule (requested of them in our first letter) and finding days during which most of them had at least one free hour. Post cards were then mailed to each student asking them to come to the testing room (on their own campus) sometime during that day. Only one of the tests was timed, so the testees could come and go at their convenience. No-shows were telephoned and encouraged to come to the next arranged testing day. About eight such sessions were necessary to complete the group testing at each college. Individual Rorschach interviews

were scheduled at the group sessions or by telephone. These interviews were also conducted at each campus, the average time being about one hour per student.

Instruments Being Used:

As the final paragraph of the rationale section pointed out, it is desirable to utilize three categories of predictors: ability, personality, and environment. The decisions about what particular observations should be made during this first year's testing program were based upon the consideration of several factors. Previous research served as the major basis for deciding which major areas demanded attention. The standardized tests which would contribute information to the desired personality and ability predictive systems were then chosen largely on the basis of their characteristics as reliable measuring instruments and their general availability (so that others might easily duplicate these procedures).

The environmental information was secured by questionnaires and interviews of our own design. The particular items composing these instruments were also based upon previously observed group tendencies for scientists and engineers and also from studies of college attendance. The initial testing program is outlined below. Copies of the mimeographed material are available on request.

Fifth Grade Group

1. STEP Science Test, Form 4A. (The STEP tests are Sequential Tests of Educational Progress published by Educational Testing Service.)
2. STEP Mathematics, Form 4A.
3. STEP Reading, Form 4A.
4. Reed Activities Index. (A modification of an instrument designed to measure the extent of voluntary student participation in science type activities.)
5. Chores Check List. (This mimeographed instrument was adapted from Super's Career Pattern Study. It attempts to determine the extent to which students are given work responsibilities at home and the student's reaction to these responsibilities.)

6. Home Scale.(A mimeographed check list which gives an index of socio-economic status.)
7. Student questionnaire. (Family and personal background, school activities.)
8. Parent Questionnaire.* (Family background, parental employment and activities, and their career hopes for their son.)
9. Interview and Projective Testing.(Questions and selected TAT cards were designed to yield information about authority and affection figures and role models. Individual standardized Rorschachs were also administered.)

Eighth Grade Group (No explanation is given where items are similar to those explained in the fifth grade list.)

1. STEP Science, Form 3A.
2. STEP Mathematics, Form 3A.
3. STEP Reading, Form 3A.
4. Reed Activities Index.
5. Chores Check List.
6. Home Scale.
7. Student Questionnaire.
8. Parent Questionnaire.
9. Student Interview. (Sought information about the student's present spare-time activities, in-school activities, career plans, self-ratings, and interpersonal relations.)

Eleventh Grade Group

1. STEP Science, Form 2A.
2. STEP Mathematics, Form 2A.
3. California Test of Mental Maturity, Short Form. (Administered by five of the schools themselves as part of their regular testing program.)
4. Guilford-Zimmerman Temperament Survey. (Published by the Sheridan Supply Company, Beverly Hills, California.)
5. Kuder Preference Record, Vocational, Form CH. (Published by Science Research Associates, Chicago, Illinois.)
6. Home Scale.
7. Student Questionnaire.
8. Chores Check List.
9. Student Interview.(Similar to one used for eighth grade students)
10. Parent Questionnaire.

College Groups

1. Strong Vocational Interest Blank for Men, Revised. (Published by Stanford University Press, Stanford University, California.)
2. Guilford-Zimmerman Temperament Survey.
3. Allport-Vernon-Lindzay: Study of Values. (Published by the Houghton Mifflin Company, Boston, Massachusetts.)
4. Thematic Apperception Test. (Six-picture form devised by David McClelland. It is a written and group administered test. These are scores for three motives: power, achievement, and affiliation.)
5. Standardized Rorschach. (Individually administered.)

* There was 98.6% return on the 500 parent questionnaires. The initial request letter is in the appendix. Post cards, phone calls, and personal visits were used in the follow-up.

6. Home Scale.
7. Student Questionnaire.
8. College Board scores are available as a measure of academic aptitude. Also, we intend to examine their high school and college records.

Additional testing will be conducted this current academic year (1959-60) and the projective testing of the eighth and eleventh grade subjects will be completed. Current career plans for everyone will be obtained each year of the study.

An important but difficult aspect of the data collection task is the development of a procedure for describing the scientific environment these students are being exposed to in the nine school systems. This is being done because we are firmly convinced that the school's science program is functionally related to career development in science. We are not hoping to find procedures for producing potential scientists in large quantities, but rather to identify programs which give students a concept of science and scientists which make rational career decisions possible. Preliminary observations of the science programs were begun last year.

EXAMPLE OF DATA ANALYSIS

On pages 14 and 15 of this paper I briefly described a possible procedure for processing data for the purposes of predicting the stability criterion previously defined. As a final section of this interim report, the analysis of twenty scores from two of the personality instruments administered to the eleventh grade group will be described in order to illustrate those suggested procedures.

The two personality instruments[1] yield ten scores of vocational

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[1] Kuder Preference Record, Vocational, Form CM. Published by Science Research Associates, Chicago, Ill.
Guilford-Zimmerman Temperament Survey. Published by Sheridan Supply Co., Beverly Hills, Calif.

interests and ten temperament scores. This means the analysis begins with a twenty dimensional interest-temperament space in which each of the 190 eleventh graders is represented by a point, the coordinates of which are the twenty original scores on the two instruments. The first task is to examine this personality space in order to determine what types of career plans are common to points in the same region of that space (i.e., are common to people having similar interest-temperament profiles).

A convenient way to inspect an n-dimensional hypersphere is to divide it into 2^n hyperoctants, and then examine the points (individuals) in each hyperoctant. But this procedure is impractical when n is greater than four or five, for there are soon more hyperoctants than people. (For instance, when n equals five there are 32 hyperoctants.) A way out is to reduce the number of dimensions needed for describing the relative locations of this swarm of points. Principal components analysis will define the minimum number of independent dimensions needed for describing most of the information about individual differences which the original twenty variates contain.

The principal components factor analysis of the twenty interest-temperament scores was carried out on the UNIVAC at the Harvard Computation Laboratory and some of the results of that analysis are presented in Tables II and III. (Tables and figures for this section follow page 30.) In this one run we computed each student's standard scores on the original variates, his new factor scores, and his distance from the origin in the factor space. The latter was necessary since two people very near the origin might be in different hyperoctants even though they have similar profiles.

Summary sheets were then prepared for each student. On each sheet

was recorded information from the student's folder summarizing briefly his career plans, family information, and pertinent test score data. We also recorded the first eight factor scores (in deviation form) and his distance from the factor space origin. The sheets were then arranged into sixteen hyperoctants by sorting into piles according to the pattern of plus and minus scores.

An inspection of the career goals described for the boys in each pile soon revealed a very definite trend. Table IV lists the first choice career goals of the boys in hyperoctants (+ + + -) and (- - - +). There is an obvious people-oriented, thing-oriented differentiation. It is perhaps reasonable to expect that students with people-oriented career goals will occupy different regions of an interest-temperament space than will those whose goals are not primarily people-oriented. Also, there may be little reason to expect lawyers to occupy a region much different than that occupied by students moving towards careers in business. The same might be said for chemical engineers and physicists. At least this is what seemed to happen here, so it was decided to compute a two-group discriminant function which involved some sort of a people-oriented career goal distinction, rather than try to make more specific distinctions.

However, since we are mostly interested in developing equations which are useful for guidance purposes, it was decided to use the Potential Scientist Pool classification for deciding in which group an individual was now a member. Therefore each student was assigned to the PSP group or the non-PSP group depending upon whether or not he was heading toward a career which required at least four years of college work in a science or engineering. We then projected all the points in the factor space (defined by the first ten factors) onto one final axis oriented in the factor space

such that the overlap between the two groups is a minimum. The discriminant weights which are used in this final reduction to a single coordinate are listed in Table V. These weights are computed very easily because the factor scores are independent and multiple regression analysis is applicable to this two-group case.

A histogram of the two groups is presented as Figure 3. The shaded areas represent individuals who are heading toward careers in science and technology. It is clear that the PSP tends to lie along the negative end of this axis. Our hypothesis is that students who emigrate from the PSP over the next four years will tend to be those closest to the positive end of this dimension.

We expect to duplicate this type of analysis for ability and environmental information for this group and for all three types of variates for the other four age groups. These analyses will be considered in subsequent reports. We will also include in a future report the details of this present analysis, including tests of significance for the two group mean vectors and covariance matrices, the significance of the principal components, interpretation of the factor and discriminant weights, etc. All that was thought necessary in this report was a demonstration of a possible procedure for dealing with the stability criterion described in the rationale section of this report.

Table II

Latent Roots and Vectors of the Interest-Temperament Correlation Matrix

The Latent Roots

Root Number	Latent Root	Cumulative Root Sum	Proportion of Trace Included
1	3.1783	3.1783	.159
2	2.5900	5.7683	.288
3	2.3231	8.0914	.405
4	1.9294	10.0208	.501
5	1.5457	11.5665	.578
6	1.4021	12.9686	.648
7	1.1107	14.0793	.704
8	.8469	14.9262	.746
9	.8035	15.7297	.786
10	.6906	16.4203	.821*

Trace = 20.0000

* The reason so many factors are required to reach a proportion this large is that the ten scales on each test are already somewhat independent and there were only eleven significant relationships between the interest and temperament scales.

Table III

The Six Significant* Vectors

Variate	1	2	3	4	5	6
1 activity	-.2599	.0036	.2337	.1007	-.2265	-.2964
2 restraint	-.1980	.0545	-.4124	.2283	-.0862	.0031
3 ascendance	-.2743	.0049	.3481	.1756	-.2578	-.1645
4 sociability	-.3334	-.0061	.3403	.0799	-.1673	-.0685
5 stability	-.3882	-.1521	.1071	-.1165	-.1223	.1972
6 objectivity	-.3713	-.2194	-.0123	-.1011	.0404	.3659
7 friendliness	-.1813	-.1758	-.3294	-.0170	.0665	.4098
8 thoughtfulness	-.0899	.0838	-.2596	.1438	-.2126	-.1729
9 personal relations	-.3336	-.0728	-.0909	.0053	.0760	.1877
10 masculinity	-.0434	-.3430	.1927	-.2375	.0133	.0578
11 outdoor	.2350	-.3538	.0029	.2550	-.0913	.1488
12 mechanical	.1173	-.4591	.0833	-.1472	-.0699	-.1742
13 computational	-.2891	-.0398	-.2629	-.1730	.1812	-.3666
14 scientific	-.1226	-.3336	-.0764	.3124	.1936	-.2361
15 persuasive	-.0404	.3669	.2697	-.2256	.0660	.1813
16 artistic	.2463	-.1477	-.0420	-.1248	-.5063	.1011
17 literary	-.0669	.3001	.0181	.1738	-.1054	.2312
18 musical	-.0620	.1914	-.1922	-.0396	-.4330	.1255
19 social service	-.0102	.0982	.2415	.3374	.4752	.1375
20 clerical	-.1608	.1523	-.2314	-.4436	.0775	-.3122

* Significant in the sense that over half of the loadings are greater than the critical value derived from formulas refined by E. A. Cureton in "A note on the use of Burt's formula for estimating factor significance". The British Journal of Psychology, Statistical Section, VIII (May, 1955) p. 28.

Table IV

First Choice Career Goals for Boys in Two Opposite Hyperoctants of the Reduced Interest-Temperament Space

+ + + -	- - - +
Salesman	Electrical Engineer
Business Administrator	Electronics Engineer
Business Administrator	Doctor
Lawyer	Geologist
Lawyer	Electrical Engineer
F. B. I.	Civil Engineer
Traffic Manager	Nuclear Physicist
State Department	Electrical Engineer
Pharmacist	Chemical Engineer
Physical Education Teacher	Electrical Engineer
History Teacher	Electrical Engineer
Physical Education Teacher	Musician
Architect	Ministry
Psychologist	
Engineer	

Table V

Weights Used in Computing the Discriminant Scores From the First Ten Factor Scores

Factor Number	Standard Deviation Along Principal Axis	Beta Weight[1]	Regression Weight[2]
1	1.782	.2079	.0583
2	1.609	.1873	.0582
3	1.524	.1767	.0579
4	1.389	-.3563	-.1281
5	1.243	-.0918	-.0369
6	1.184	.2199	.0928
7	1.0539	.0673	.0319
8	..9203	.0136	.0074
9	.8964	-.1644	-.0916
10	.8309	.0045	.0027

[1] The multiple correlation coefficient derived from these beta weights is 0.57

[2] Regression weights were computed and these are proportional to the two group discriminant weights.

PAGE 33 - FIGURE 3 - "HISTOGRAM OF THE INTEREST-TEMPERAMENT DISCRIMINANT FUNCTION" removed prior to being shipped to EDRS for filming due to marginal legibility of original.

APPENDIX

Staff:

What we have been able to accomplish this first year of the project has been largely due to the able assistance of graduate students working as part-time research assistants and to the aid of a competent full-time secretary.

Research Assistants:

David Berlew
Ronald Dutton
Florence Fried
Brete Huseth
Nona Lipofsky
John Mierzwa
Edward Scanlan
John Stout

Secretary:

Elaine Purpel

Undergraduate Assistant:

Judith Cohen, Bennington College

Consultants:

On July 11, 1958 the project consultants met as a group to discuss the general design of this investigation. Since then they have been individually contacted for advice when problems arose in their areas of competence. Actually, faculty other than those listed are also interested and have given advice when called upon, but the list below is the official roster. Because of their limited contact with this project, however, they cannot and must not be held responsible for its shortcomings.

J. B. Carroll
G. W. Goethals
R. C. Hummel
C. C. McArthur
P. J. Rulon
D. V. Tiedeman
F. G. Watson

(Initial letter to 500 parents)

HARVARD UNIVERSITY

GRADUATE SCHOOL OF EDUCATION

Batchelder House
7 Kirkland Street
Cambridge 38, Mass.

Dear Parents:

Nine school systems around Boston are working with Harvard University on a five-year study of career development for the U. S. Office of Education. The results may be of national importance in improving guidance services to students as they make decisions about school courses and programs.

In your local schools, your son has been selected as one of a group of boys from the 5th,, 8th, or 11th grade. Each group will be interviewed and given aptitude, job-interest, and other tests at school during the regular school hours. The testing results will be available to your school's guidance director, but otherwise the material on individuals will be kept confidential.

Probably we will ask later if you can spare half an hour or so to tell us about your son's interests, and about your ideas on what kinds of work he does well.

If you do not wish to have your son stay in the research group, please have him bring the attached card back to his school principal's office. Since seven hundred boys are involved, we will have to assume that you are willing to have him included if we do not hear from you by October 31.

Please drop me a note or call my office (UNiversity 8-7600, extension 2544) if you would like any more information.

Sincerely yours,

William W. Cooley, Director
Vocational Development Study

WC:ep

Enclosure

HARVARD UNIVERSITY

GRADUATE SCHOOL OF EDUCATION

Batchelder House
7 Kirkland Street
Cambridge 38, Mass.
February 6, 1959

(Letter accompanying parent questionnaire)

As you know, your son is one of a group of boys participating in a study of how, when and why certain types of jobs are chosen and pursued. Nine school systems and five colleges are cooperating with Harvard University in this study sponsored by the U. S. Office of Education.

The purpose of this letter is to seek your cooperation. We realize that the parents often play an important part in helping boys decide on reasonable career plans. Also, the people most likely to understand boys and their vocational plans are the parents, who are able to observe this whole process of growing up and choosing a career. Therefore, we need some information from you. Please answer the attached questions and mail the completed form in the enclosed stamped envelope.

Your cooperation in this study is necessary if we are going to be able to continue including your son. We will greatly appreciate your returning the questionnaire as soon as possible.

It is our belief that, although your specific answers will be seen only by our research staff, the combined answers of the parents included in this study will greatly assist young boys like your son as they go through school.

Sincerely,

William W. Cooley, Director
Vocational Development Study

WC:ep

HARVARD UNIVERSITY

GRADUATE SCHOOL OF EDUCATION

(Initial letter to college students)

Dear Mr.

This fall we are undertaking an extensive research project which will attempt to give us some insight into the process of vocational choice. It is hoped that the resulting information will be useful in guiding future college students in their career development. So that we might have a broad sample of students in our study, a number of colleges and universities in this area have agreed to let us ask some of their students to participate, and your school is one of them.

The purpose of this letter is to seek your assistance. We would like you to be one of the students included in our sample. It will involve 2 or 3 hours of testing and a short interview this first year, and then we will attempt to maintain some contact with you for the next five years through post cards and short questionnaires. We will also seek your permission to include your academic records in our analyses. All testing and interviewing will be done at your school.

So that we can arrange a time to meet with you, please fill out the enclosed card and mail it to us as soon as possible. Fill out the top three lines as indicated, adding the name of your school after your name. Place X's in the spaces indicating when you have classes or other weekly engagements, changing the times on the card if they do not correspond to your hours.

If you feel that you are unable to participate in this research project, we would appreciate your letting us know, either by letter or phone, telling us, if you care to, why you prefer not to take part.

Also, if you have any questions or uncertainties about participating, call and we will be happy to discuss them with you. Our phone number is UNiversity 8 7600, extension 2544. Thank you for your cooperation.

Sincerely,

William W. Cooley, Director
Career Development Study

WC:ep

Enclosure

The Scientific Careers Study

W.W. Cooley, Principal Investigator

In June, 1958 the U.S. Office of Education made a grant to the Harvard Graduate School of Education to undertake a five-year study of career development, with special attention to scientific careers. The summer of 1958 was spent in organizing the mechanical details of selecting, testing, interviewing and following 700 boys for five years. The actual data collection began in the fall of 1958. We are now beginning the third year of this enterprise, called the Scientific Careers Study.[1]

The general purpose of the Scientific Careers Study is to examine the process of becoming a scientist, from elementary school through four years of college, in order to determine the major factors affecting that process. An overlapping longitudinal design is employed so that a sixteen-year developmental span can be studied in only five calendar years. This involved selecting 700 male students from five different grade levels, three grades apart. Table I shows the grades covered by the five groups and the number of students included in each.

Table I

Grades Covered and Size of the Five Groups

Sample Group	Number	Grades Covered
A	143	5 6 7 8 9
B	167	8 9 10 11 12
C	192	11 12 13 14 15
D	105	14 15 16 + +
E	90	16 + + + +
Total	697	

[1] Individuals are considered to be pursuing scientific careers whose educational decisions and sequence of positions involve working toward or in positions which require at least a four-year college major in one or more of the natural sciences or engineering.

The two years of overlap between the five groups will allow comparisons between the groups. It is not our desire or expectation to be able to predict which fifth graders will become Ph.D's in theoretical physics, but rather to identify factors which are related to educational and career decisions made at the various stages of development.

The sample sizes are small enough to permit the careful study of individual students and the various determinants of their career development. However, the five groups are sufficiently large to make applicable modern techniques of multivariate analysis in the search for general principles.

Students (all boys)[1] were chosen at random from nine school systems and six colleges in eastern Massachusetts after first applying the following eligibility criteria:

1) all fifth and eighth graders were above the 50th centile on previously administered tests of general intelligence and in school achievement.

2) all eleventh graders were above the 50th centile in general intelligence and school achievement and were taking the college preparatory curriculum.

3) the college boys were all majoring in science, mathematics or engineering, and graduated from high schools for which our nine school systems are representative (eastern Massachusetts).

The data collection includes: interviews of students and teachers; standardized achievement and aptitude tests; personality and interest inventories; questionnaires for students and parents; and two projective instruments.

The over-all rationale for this investigation was derived from the newly emerging developmental theories of vocational behavior, combined with a modification of the classical trait and factor approach based on the psychology of individual differences. In many respects our rationale is similar

[1] Restricting the study to males was necessary since male and female data must be considered separately in studies of this sort, and this would have doubled our entire operation. We acknowledge the existence of females, admit that almost 10% of the current scientific manpower pool are females, but we cannot consider them in this investigation.

to the theoretical synthesis of the trait and factor committee of the Arde House conference on scientific careers, and in all respects it has been influenced by the monograph resulting from that conference.[1] (Local participants were D.V. Tiedeman, A. Roe, R.C. Hummel, and C. McArthur.)

Our goal is not toward a static description of how scientists as a group differ from other professionals or the general population, but rather toward a dynamic explanation of movement into, within and out of scientific careers. We are focusing on a single occupational area as a research expediency and upon scientists in particular because of a personal interest. We shall attempt to describe movement into science and the exploration for a particular career once there. The big question is: What are the types of decisions one has to make in moving into a scientific career and what factors are associated with the possible outcomes of those decisions? "Factors" here include dimensions of individual personality and aptitude and also dimensions of environmental phenomena (family, school, community, etc.). However, our emphasis on the choice process has necessitated a concentration on personality assessment.

Perhaps the following model will help you visualize what the Scientific Careers Study is trying to do. Each of our five age groups were selected from what is essentially the Potential Scientist Pool (PSP) at that stage of development. (See selection criteria on page 2.) The PSP defines the pool of boys who could pursue professional careers in the fields of science and technology. "Could" because they have attributes consistent with those known to be needed for continued professional training and because they have made educational decisions which make possible further education in the science and mathematics. The PSP, then, includes the future scientists and

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1 Super, D.E. and Bachrach, P.B. Scientific Careers and Vocational Development Theory. New York: Bureau of Publications, Teachers College, Columbia University, 1957.

also their classmates for whom science careers are still possible but who will eventually decide on other careers. The existing criteria for deciding who is in the PSP become more specific as we go from fifth graders to college students, but they still include many more people than do actually continue careers in science. Our hope is that the Scientific Careers Study will make possible more specific statements for defining the PSP at the various stages of development.

There are two general types of criteria we are dealing with in this investigation, educational decisions and career plans. The first category of criteria is based upon the various types of educational decisions each age group is being forced to make during the five years of follow-up. The other type of criteria is derived from the student's stated career plans. We are interested in predicting the stability of these career goals, especially for boys considering scientific careers. Also, the relationships between the two are important. Some school decisions will mean movement out of the PSP if the student chooses a course of study which would make a scientific career highly unlikely.

So you see we are concerned with a variety of criteria: which high school curricula; college or not; science major or non-science major; graduate school or not; scientific career plans or not. It is not just a matter of dumping all our observations into one big discriminant function for scientists and non-scientists! Some systems of data may be useful for predicting certain types of criteria and not others. The Rorschach, for instance, may <u>not</u> predict who goes to college, but it might distinguish between boys who enter careers which are highly people-involved and those boys who don't, and this seems relevant to our problem.